General Electric Systems Technology Manual

Chapter 4.2

Secondary Containment System

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4.2 SECONDARY CONTAINMENT SYSTEM

Learning Objectives:

1. Recognize the purposes of the Secondary Containment System.

2. Recognize the function and operation of the following secondary containment features:
   a. Reactor building
   b. Relief panels
   c. Airlocks
   d. Reactor building normal ventilation system
   e. Unit area coolers
   f. Primary containment purge system

3. Recognize the plant conditions that will cause the Reactor Building Normal Ventilation System (RBNVS) to isolate.

4. Recognize the following flow paths:
   a. Air transfer through the RBNVS
   b. Purge vent & exhaust from primary containment

5. Recognize the various types of secondary containment penetrations and how they perform their isolation function.

6. Recognize how secondary containment equipment responds to an accident signal.

7. Recognize how the Secondary Containment system interfaces with the following systems:
   a. Primary Containment System (section 4.1)
   b. Reactor Building Standby Ventilation System (Section 4.3)
   c. Nuclear Steam Supply Shutoff System (Section 4.4)

4.2.1 Introduction

The purposes of the Secondary Containment System are:

- minimize the ground level release of radioactive material following an accident
- to provide primary containment when the drywell or suppression chamber are open.

A failure of the secondary containment under accident conditions could result in an unmonitored and undiluted ground release of radioactive sufficient to challenge the compliance with 10CFR100 exposure limits.

The functional classification of the Secondary Containment System is that of a safety related system. Its regulatory classification is that of an Engineered Safety Feature (ESF) system. The Secondary Containment System consists of the:

- the physical boundary of the reactor building and
- the RBSVS.

The reactor building and its normal ventilation system are described in this chapter. The RBSVS is covered separately in Chapter 4.3.

The reactor building encloses the entire primary containment boundary which consists of the drywell and suppression chamber. The reactor building and the RBSVS provide a second containment barrier to fission product release. Facilities and systems that transport or contain potentially contaminated water / steam in the reactor building include:

- Refueling and reactor service areas
- New and spent fuel storage facilities
- Reactor core isolation cooling system (RCIC)
- Reactor water cleanup system (RWCU)
- Standby liquid control system (SLC)
- Control rod drive system (CRDH)
- Emergency core cooling systems (ECCS)

The RBNVS supplies filtered air to and exhausts air from the secondary containment. It maintains the reactor building internal pressure at -1.5 inch water gage pressure. This negative pressure ensures that any leakage through the secondary containment boundary is from outside to inside the reactor building.

Access to the reactor building is provided by double door air locks and an equipment access hatch.

4.2.2 Component Description

The major components of the Secondary Containment System are discussed in the paragraphs which follow.

4.2.2.1 Reactor Building

The reactor building is a cylindrical concrete structure designed to withstand tornado loads and missile hazards from the foundation mat to the top of the polar crane rail above the refueling floor. The reinforced concrete structure protects all of the safety systems in the reactor building (including the primary containment) necessary for the safe shutdown of the plant. The superstructure of the reactor building above the polar crane rail consists of a structural steel frame covered with metal siding and a reinforced concrete roof. The metal siding is not required for tornado protection and may be lost under this loading. In addition, relief panels (vents) are installed to prevent the buildup of excessive pressure differentials between the reactor building and surrounding atmosphere.

4.2.2.2 Relief Panels

Excessive reactor building pressure differentials caused by steam line ruptures and tornadoes are prevented by venting the secondary containment to atmosphere. These vents consist of:

- turbine building blowout panels
- main steam tunnel relief vents
- the reactor building exterior metal siding.

Steam ruptures occurring in the main steam pipe tunnel are relieved to the turbine building through the main steam tunnel relief vent. The interconnecting network of floor gratings in the reactor building enable pressurization effects of main steam and other high energy pipe ruptures to migrate to the refueling floor. The refuel floor exterior siding panels vent the refueling floor to the outside atmosphere.

4.2.2.3 Air Locks

Entry to and exit from the reactor building are through double door personnel and equipment air locks. Each pair of access doors is equipped with rubber weather-strip type seals. The doors are electrically interlocked so that only one of the pair may be opened at a time.

4.2.2.4 Reactor Building Normal Ventilation System

The Reactor Building Normal Ventilation System (Figure 4.2.2) consists of:

- heating and air conditioning supply units with two supply fans
- three exhaust fans
- distribution ducts
- manually positioned ventilation louvers
- differential pressure controlled dampers
- unit coolers
- controls and instrumentation.

The reactor building is heated, cooled, and ventilated during normal operating and shutdown conditions by the Reactor Building Normal Ventilation System (RBNVS). Even though the RBNVS is not an engineered safety feature, certain components do perform engineered safety feature functions. Those components include:

- system supply and exhaust isolation valves
- reactor building exhaust fans
- safety related equipment area unit coolers.

The RBNVS maintains a sub-atmospheric pressure such that containment leakage is into rather that out of the containment boundary. This prevents unmonitored air leakage to the environment. Negative pressure is developed by automatic positioning of the reactor building supply fans discharge pressure control dampers (PCD-11A/B) so that reactor building ventilation exhaust flow is greater than supply flow. The parameter used to modulate the dampers is a differential pressure signal developed by comparing reactor building internal pressure with outdoor atmospheric pressure.

During periods when access is required to Primary Containment, the RBNVS replaces the Primary Containment atmosphere with fresh air prior to personnel entry and then continues to provide fresh air during maintenance via the Primary Containment Purge System.

The RBNVS is automatically shutdown and isolated whenever the secondary containment is isolated and subsequently connected to the RBSVS.

Outdoor air is drawn from a louvered intake in the reactor building south wall through two air operated isolation valves (AOV-35A/B) and supplied to the suction of both supply fans. One of the two 100% capacity fans is normally operating and supplying 89,000 scfm to the reactor building. This flow rate equates to approximately 2.5 air changes per hour. Fresh air then passes from the supply fan through its discharge PCD 11A/B and on to a glycol heating coil which operates as necessary to maintain supply air temperature at 60ºF. Should the outside temperature drop to 35ºF, supply valves AOV-35A/B will close to prevent downstream coolers from freezing. This will also result in an automatic initiation of the Reactor Building Standby Ventilation System and simultaneous isolation of the RBNVS.

Air leaving the heating coil is filtered and then distributed via ducts to all levels of the Reactor Building (Secondary Containment).

- One duct supplies air for primary containment purge when required
- A second duct directs air to the refueling level
- A third duct supplies air to all other levels.

Air supplied to the refuel and reactor building areas passes through chilled water coolers and individual area heaters prior to being distributed to the various levels.

Exhaust air is drawn from and collected in the reactor building exhaust plenum from:

- each reactor building floor level
- potentially contaminated areas
- steam pipe tunnel
- refuel floor

If the refuel area ventilation exhaust radiation monitor detects a high radiation condition at the exhaust duct, downstream exhaust isolation valves AOV-40A/B are signaled to close before any radioactive gases are released.

Three 50% capacity Reactor Building Exhaust Fans (45,000 scfm each) draw air from the exhaust plenum and discharge through RBNVS discharge isolation valves AOV-37A/B. Two of the three exhaust fans are usually in operation providing 90,000 scfm exhaust flow. Exhaust air is discharged from the reactor building via the station ventilation exhaust stack. Normal ventilation air exhaust is not filtered prior to release but is continuously monitored for radioactivity. High activity will isolate the secondary containment and start the Reactor Building Standby Ventilation System.

Air supplied to the refueling zone is distributed to one side of the refueling room and then flows directionally from the area of least towards the area of most potentially contaminated sections of the room. It is collected around the periphery of the fuel storage pool (including the dryer and separator pool and refueling well when primary containment is open) and other areas of high potential for contamination.

Fresh air is directed into each reactor building area from the air supply ducts to that floor. Air is swept through open areas and rooms and is then collected for exhaust by the ventilation exhaust ducts located within those areas. Rooms below grade level are also ventilated by air moving down open stairwells and equipment floor grating to each of the corner rooms and then collected for exhaust by the room(s) exhaust ducts.

4.2.2.5 Area Unit Coolers

Area unit coolers are installed in various areas of the reactor building to supplement the RBNVS. They consist of a filter, cooler and fan. Certain equipment room unit coolers are supplied power from the plant Emergency AC Power System. This ensures that safety related equipment is sufficiently ventilated and cooled to enable them to continuously perform their design functions. When the RBSVS starts RHR/Core Spray Area and Refueling Area unit coolers operation is initiated. Additional units, such as those located in vital Motor Control Center (MCC) areas and MG Set Rooms are started and stopped automatically as controlled by area temperature sensor switches.

Cooling water is supplied to the area unit coolers by the RBSVS/Control Room Air Conditioning Chilled Water System which is also available during accident or loss of normal power situations. Supplemental cooling is provided in the Steam Pipe Tunnel. Reactor Water Cleanup (RWCU) Pump Rooms, and the RWCU Heat Exchanger area are cooled by unit coolers located within those rooms.

All areas are cooled or heated as necessary to maintain maximum exhaust temperatures of about:

- 130ºF in the main steam pipe tunnel
- 110ºF on the refueling level
- 100ºF in the remainder of the secondary containment

4.2.2.6 Primary Containment Purge System

The Primary Containment Purge System (PCPS) consists of connections to the RBNVS supply and exhaust ducting and a dedicated filter train unit for processing primary containment effluent atmosphere prior to release. The drywell and suppression chamber are supplied with fresh air from the purge system whereas exhaust air is processed by the PCPS filter train, directed to the RBNVS exhaust ducting for discharge through the station exhaust stack.

The PCPS filter train consists of:

- a high efficiency particulate absolute (HEPA) filter
- a charcoal adsorber
- a fan

The HEPA filter can remove radioactive particulate matter of 0.3 micron size and larger with an efficiency of 99.95%. The charcoal adsorber is an activated charcoal bed. The adsorber unit is capable of removing >99.95% of radioactive iodine in the form of elemental iodine and 85% of radioactive iodine in the form of methyl iodide with the flow at 90% relative humidity. The fan at the end of the train provides system flow and delivers 1000 scfm at 8.5 inches water gage pressure.

If the Primary Containment Purge System is in service and the RBSVS is initiated, the purge system will automatically isolate and its running fan will stop.

4.2.3 System Features and Interfaces

A short discussion of system features and interfaces this system has with other plant systems is given in the paragraphs which follow.

4.2.3.1 Secondary Containment Integrity

The operational conditions that require that secondary containment integrity must be maintained include:

- all times that primary containment integrity is required (i.e.; the reactor is critical or moderator temperature is >200ºF and fuel is in the reactor vessel)
- when fuel handling operations are in progress within the secondary containment
- when activities are being performed that have a potential for draining the reactor vessel.

Secondary containment integrity means that the reactor building is intact and that the following conditions are met:

- The Reactor Building Normal Ventilation System automatic isolation valves are operable or deactivated in the closed position.
- The Reactor Building Standby Ventilation System is operable.
- Secondary containment pressure is less than or equal to -1.5 inch H_2O gauge.
- Secondary containment leakage rates are within specified limits.
- All containment penetration seal mechanisms are operable.
- At least one door in each access opening is closed.
- All equipment hatches are closed and sealed.

4.2.3.2 Normal Operation

Secondary containment integrity is maintained during normal operations. The Reactor Building Normal Ventilation System is in service maintaining a slight vacuum (-1.5" H_2O pressure) throughout the secondary containment volume. Reactor building ventilation exhaust is monitored for radioactivity but is not filtered.

4.2.3.3 Infrequent Operation

The primary containment is inerted with nitrogen gas during normal operation. When the plant is shutdown for an outage, it is necessary to de-inert the primary containment to allow for personnel entry. This is accomplished by supplying fresh air to the primary containment from the RBNVS and using the Primary Containment Purge System (PCPS) to exhaust primary containment atmosphere (nitrogen gas and air) until the oxygen concentration >19.5%. The PCPS receives, filters (when unacceptable radiation levels exist), and then discharges primary containment effluent to the RBNVS exhaust ducting.

4.2.3.4 System Isolations

Certain RBNVS valves are closed automatically as part of the isolation logic of the Nuclear Steam Supply Shutoff System (NSSSS), Radiation Monitoring Instrumentation, and RBSVS. The isolation signals provided by those systems are listed below:

- High drywell pressure high ($\geq$1.69 psig)
- Reactor vessel low low level (Level 2, -38 inches)
- Refuel area exhaust ventilation radiation high ($\geq$35 mR/hr)
- Vent/purge exhaust ventilation radiation high ($\geq 5.4 \times 10^5$ cpm)
- Reactor Building low ΔP (> -0.30" H_2O)
- RBSVS initiation signal, multiple inputs.

The RBNVS automatically isolates by shutting the reactor building supply valves AOV-35A/B exhaust valves AOV-37A/B. When these valves shut the RBSVS will start, if it is not already running. Initiation of the RBSVS results in additional ventilation system actions including:

- trips the running reactor building supply fan
- shuts the refueling area exhaust dampers
- shuts the contaminated area exhaust dampers
- shuts the primary containment purge supply and exhaust valves (if open)
- the running reactor building exhaust fans continue operating to provide building recirculation
- area unit coolers start and/or cycle as described above

These system realignments isolate the secondary containment and places RBSVS in operation which:

- preserves a slight negative pressure in the secondary containment
- provides internal recirculation and cooling of the reactor building atmosphere
- controls, filters and elevates any release of the building atmosphere to the environment.

4.2.3.5 System Interfaces

Interfaces between the Secondary Containment System and other plant systems are discussed in the following paragraphs.

Primary Containment System (Chapter 4.1)

The RBNVS can supply fresh air to and receive atmosphere vented from the primary containment via the PCPS. Additionally, the secondary containment serves as the primary containment when the drywell or suppression chamber are open.

Reactor Building Standby Ventilation System (Chapter 4.3)

The RBSVS starts automatically during accident conditions to maintain the secondary containment volume at a slight negative pressure and provide a controlled, filtered, and elevated release of reactor building atmosphere. Cooling water is supplied to the area unit coolers by the RBSVS/Control Room Air Conditioning Chilled Water System.

Nuclear Steam Supply Shutoff System (Chapter 4.4)

Several RBNVS isolation valves are automatically closed by the NSSSS.

Emergency AC Power (Chapter 9.2)

Certain equipment room unit coolers are supplied power from the plant Emergency AC Power System. This ensures that safety related equipment is sufficiently ventilated and cooled to enable them to continuously perform their design functions. Emergency AC power is available to RBNVS fans and dampers to support operation of the RBSVS.

4.2.4 Summary

Classification - Safety related system; engineered safety feature system.

Purpose - To minimize the ground level release of radioactive material following an accident and to serve as the containment when the primary containment is not intact.

Components - Reactor building, relief panels; RBNVS; area unit coolers.

System Interfaces - Primary Containment System; RBSVS; NSSSS.

TABLE 4.2-1 Secondary Containment Design Summary

Free Air Volume	2,000,000 ft^3
Design Inleakage (at -0.5 in. H_2O)	50 % of Volume/day (≈ 700 cfm)
Containment Pressure [accident conditions - Double-ended rupture (DER) of a recirculation loop or a refueling accident]	The Reactor Building Standby Ventilation System is designed to maintain the reactor building sub-atmospheric relative to the outside environment

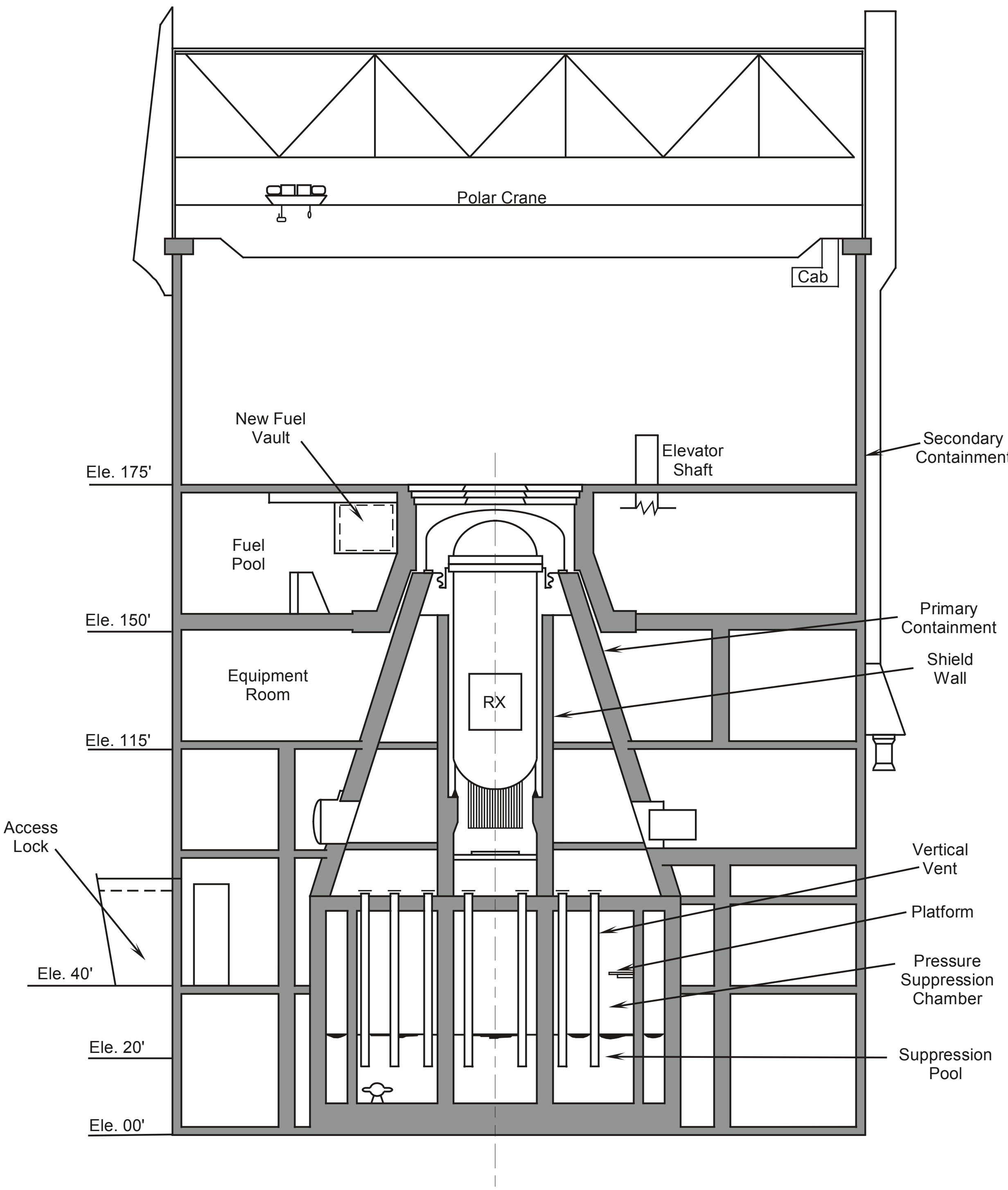

Figure 4.2-1 Mark II Containment

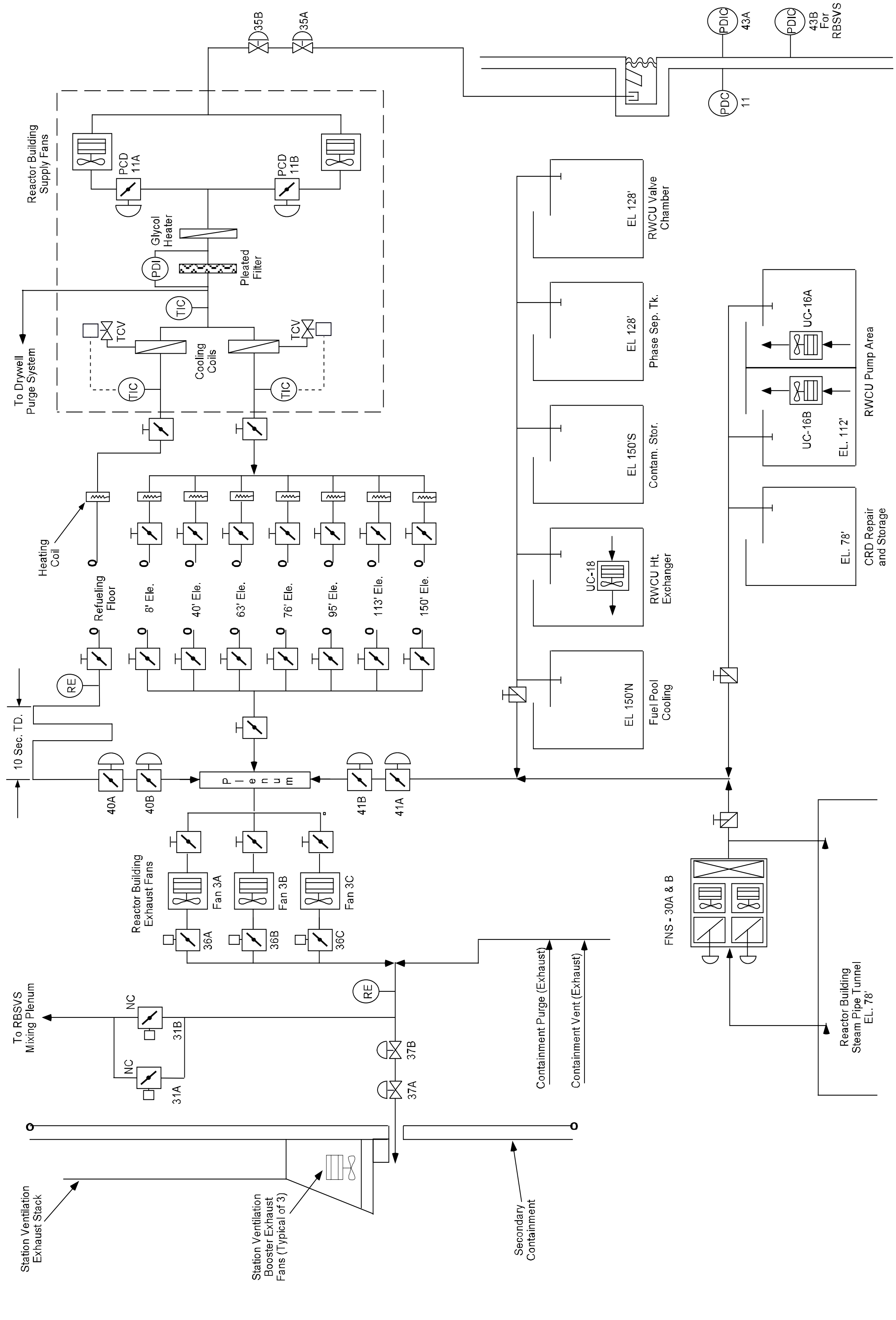

Figure 4.2-2 Reactor Building Normal Ventilation System